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(54) **OVERFIRE AIR SYSTEM FOR LOW NITROGEN OXIDE TANGENTIALLY FIRED BOILER**

OBERLUFTSYSTEM FÜR EINEN STICKOXIDARMEN TANGENTIAL BEFEUERTEN KESSEL

SYSTÈME D'AIR DE SURCOMBUSTION POUR CHAUDIÈRE À COMBUSTION TANGENTIELLE À
FAIBLE TENEUR EN OXYDE D'AZOTE

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- **MRUK, Bryan Walter**
Chicopee, Massachusetts 01020 (US)
- **SIRIANI, Christopher David**
Agawam, Massachusetts 01001 (US)

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(74) Representative: **BRP Renaud & Partner mbB**
Rechtsanwälte Patentanwälte
Steuerberater
Königstraße 28
70173 Stuttgart (DE)

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(73) Proprietor: **General Electric Technology GmbH**
5400 Baden (CH)

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(72) Inventors:
• **HELLEWELL, Todd D.**
Windsor, Connecticut 06095 (US)

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Description

TECHNICAL FIELD

[0001] The present patent relates generally to a pulverized solid fuel fired furnace system and more particularly relate to an advanced overfire air system for use with a tangentially fired boiler for ultra-low levels of nitrogen oxides with improved efficiency.

BACKGROUND OF THE INVENTION

[0002] CN 104633652 A shows a boiler with a windbox in a horizontal orientation. US 2014/0308620 A1 discloses a boiler with an overfire air system. US 2011/0094105 A1 shows a boiler with a windbox in a horizontal orientation. US 5 901 669 A discloses a furnace circuitry in which lower furnace spiral tubes connect continuously to upper furnace vertical tubes.

[0003] Generally described, a tangentially fired boiler includes a combustion chamber in which a combination of a flow of a pulverized solid combustible fuel and a flow of air is combusted to generate heat. The heat may be used for any suitable purpose such as for driving a steam turbine for producing steam and the like. The flow of combustible fuel and the flow of air may be introduced along a horizontal plane from multiple locations about the perimeter of the combustion chamber. Specifically, the flow of fuel and the flow of air may be directed tangentially to a focal region along the horizontal plane. This focal region may be substantially concentric within the combustion chamber such that combustion results in the controlled formation of a spiraling fireball.

[0004] Overfire air is combustion air that may be tangentially injected into the combustion chamber between the primary firing zone and a furnace outlet. Thorough mixing of the overfire air with the gases in the fireball may achieve low levels of nitrogen oxides, carbon monoxide, and other types of emissions with an overall increase in combustion efficiency.

[0005] Such boilers may use a combination of spiral and vertical water tubes positioned about the walls of the combustion chamber. The spiral tubes may benefit from the averaging of the lateral heat absorption variation in each water tube. Moreover, the location of the spiral to vertical transition of the water tubes may have an impact on the number of turns of the spiral wall. Specifically, too many turns may result in an increased pressure drop while too few turns may result in uneven spiral wall tube outlet temperatures. Such uneven outlet temperatures may cause thermal stresses within the tubes and the headers.

SUMMARY OF THE INVENTION

[0006] The invention provides a boiler in accordance with claim 1 and a method in accordance with claim 11.

[0007] The present patent thus provides a tangentially

fired boiler. The tangentially fired boiler includes a combustion chamber and an overfire air system positioned about the combustion chamber. The overfire air system includes a number of overfire air windboxes positioned in a substantially horizontal orientation.

[0008] The present patent further provides a method of operating a tangentially fired boiler. The method includes the steps of combusting a flow of fuel and a flow of air in a combustion chamber, circulating a fluid in a spiral configuration around the combustion chamber, and flowing overfire air into the combustion chamber via a number of horizontal overfire windboxes positioned above the spiral configuration.

[0009] These and other features and improvements of the present invention will become apparent to one of ordinary skill in the art upon review of the following detailed description and technique in conjunction with the several drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig. 1 is a schematic diagram of a solid fuel fired steam generator including an overfire air system not in accordance with the present invention.

Fig. 2 is a schematic diagram of a solid fuel fired steam generator including an overfire air system in accordance with the present invention.

DETAILED DESCRIPTION

[0011] Referring now to the drawings, in which like numerals refer to like elements throughout the several views, Fig. 1 shows an example of a pulverized solid fuel fired boiler 100. The boiler 100 may include a combustion chamber 110. A pulverized solid fuel such as a flow of coal and a flow of air may be combusted therein. The hot gases that are produced from the combustion of the pulverized solid fuel and the air rise upwardly in the combustion chamber 110 and exchange heat with water passing through a number of water tubes 120 positioned within the walls 130 thereof. (Other types of fluids may be used herein.) The hot gases then may exit the combustion chamber 110 through a horizontal pass which in turn leads to a rear gas pass. The boiler 100 may provide steam generated therein to a turbine such as used in a turbine/generator set or for any other suitable purpose.

[0012] The boiler 100 may include one or more windboxes 160. The windboxes may be positioned about the corners or the walls of the combustion chamber 110. Each windbox 160 may be provided with a number of air compartments 170. Air may be supplied from a suitable source and injected into the combustion chamber 110 via the air compartments 170. Each windbox 160 also may include a number of fuel compartments 180. A pulverized solid fuel may be injected into the combustion

chamber 110 via the fuel compartments 180. The solid fuel may be supplied to the fuel compartments 180 by a pulverized solid fuel supply 190. The pulverized solid fuel supply 190 may include a pulverizer 200. The pulverizer 200 may be in communication with the fuel compartments 180 via a number of pulverized solid fuel ducts 210. The air stream generated by the air source may transport the pulverized solid fuel from the pulverizer 200, through the pulverized solid fuel ducts 210, through the fuel compartments 180, and into the combustion chamber 110.

[0013] As described above, the walls 130 of the combustion chamber 110 may have a number of the water tubes 120 running therethrough. The water tubes 120 positioned about the combustion chamber 110 may have a spiral orientation 220. The spacing of water tubes 120 along the length of the walls 130 may vary. Specifically, the water tubes 120 may have a first or a close configuration 230 about a bottom of the combustion chamber 110 and may have a second or a separated configuration 240 about a top of the combustion chamber 110. The spacing between the water tubes 120 may vary. The water tubes 120 may transition from the spiral orientation 220 to a vertical orientation 250 at a spiral to vertical transition line 260. The transition line 260 generally may be positioned close to the top of the combustion chamber 110. A number of finger straps 265 may be positioned about the spiral to vertical transition line 260. The finger straps 265 may support the spiral orientation 220 of the water tubes 120. Other components and other configurations may be used herein.

[0014] The combustion chamber 110 may include an overfire air system 270. As described above, the overfire air system 270 may introduce separated overfire air (SO-FA) into an upper region of the combustion chamber 110. The overfire air system 270 may include a number of overfire air windboxes 280. Similar to the windboxes described above, the windboxes include a number of air compartments 170 and fuel compartments 180. The overfire air windboxes 280 generally include a vertical orientation 290. The overfire air windboxes 280 generally may be positioned below the spiral to vertical transition line 260 of the water tubes 120. Air injected normal to the surface of the combustion chamber walls 130 intercepts the approaching flow of the fireball vortex. The array within the windboxes 280 generally may tilt through about thirty degrees and yaw through about twenty-five degrees. The boiler 100 and the components thereof are described herein for the purpose of example only. Other types of boilers 100 and boiler components may be used.

[0015] Fig. 2 shows an example of a boiler 300 as may be described herein. The boiler 300 includes a combustion chamber 310. The combustion chamber 310 and the component thereof may be substantially similar to the combustion chamber 110 described above. The combustion chamber 310 also includes an overfire air system 320. The overfire air system 320 includes a number of overfire air windboxes 330. The overfire air windboxes 330 has a substantially horizontal orientation 340 as op-

posed to the vertical orientation 280 described above. In other words, the overfire air windboxes 330 may be rotated by about ninety degrees (90°). Given that a typical overfire air windbox 330 may be about two to four meters tall but only about a meter wide, the use of the horizontal orientation 340 allows the overall length of the combustion chamber 310 to be reduced by about one to three meters. Other sizes, shapes, and configurations may be used herein. Moreover, the use of the horizontal orientation 340 allows the spiral to vertical transition line 260 of the water tubes 120 to be lower and positioned underneath the overfire air windboxes 330. This lower position also allows the water tubes 120 to have a substantial uniform spacing 350 along the length of the combustion chamber 310. Other components and other orientations also may be used herein.

[0016] The use of the horizontal orientation 340 of the overfire air windboxes 330 thus allows for the optimization of the spiral to vertical transition line 260 for an improved overall pressure drop and minimum once through load. Likewise, the horizontal orientation 340 of the overfire air windboxes 330 may minimize shading of the water tubes 120 in the vertical configuration 250 above the transition line 260. Specifically, the vertical orientation 290 of the overfire air windboxes 280 may cause the water tubes 120 to be bent so as to accommodate the existing overfire air windboxes 280. The bent water tubes 120 may receive no direct heating from the fireball and thus may become cooler than the water tubes adjacent to the windboxes 280 so as to create thermal stresses. The reduced height of the horizontal orientation 340 of the overfire air windboxes 330 thus will allow for a more uniform tube-to-tube outlet temperature and a reduction in thermal stress.

[0017] Injecting the separated overfire air via the overfire air windboxes 330 in the horizontal orientation 340 as described herein thus may provide thorough mixing of the overfire air with the gases of the spiraling fireball for achieving a minimum or at least reduced emission levels with a maximum or at least improved overall combustion efficiency. Reducing the height of the combustion chamber walls 130 likewise may improve the overall thermal performance of the boiler 100 in a less expensive, simplified design.

[0018] It should be apparent that the foregoing relates only to certain embodiments of the present invention.

[0019] Numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the scope of the invention as defined by the following claims.

Claims

1. A tangentially fired boiler (300), comprising:

a combustion chamber (310); and
an overfire air system (320) positioned about the

- combustion chamber (310);
the overfire air system (320) comprising a plurality of overfire air windboxes (330);
the plurality of overfire air windboxes (330) comprising a horizontal orientation (340),
wherein the combustion chamber (310) comprises a wall (130) with a plurality of tubes therein (120),
wherein the plurality of tubes (120) comprises a spiral configuration (220),
wherein the spiral configuration (220) extends to a spiral to vertical transition line (260),
wherein the plurality of tubes (120) comprises a vertical configuration (250) above the spiral to vertical transition line (260),
wherein the overfire air system (320) is positioned above the spiral to vertical transition line (260). 5 10 15
2. The tangentially fired boiler (300) of claim 1, wherein the plurality of tubes (120) comprises a plurality of water tubes (120). 20
3. The tangentially fired boiler (300) of any one of claims 1 to 2, wherein the plurality of tubes (120) comprises a substantially uniform spacing (350). 25
4. The tangentially fired boiler (300) of any one of claims 1 to 3, wherein the combustion chamber (310) comprises a plurality of windboxes (160). 30
5. The tangentially fired boiler (300) of claim 4, wherein the plurality of windboxes (160) comprises an air compartment (170) and a fuel compartment (180).
6. The tangentially fired boiler (300) of claim 4 or 5, wherein the plurality of windboxes (160) may tilt through about thirty degrees and yaw through about twenty-five degrees. 40
7. The tangentially fired boiler (300) of any one of claims 4 to 6, further comprising a pulverized solid fuel supply (190) in communication with the plurality of windboxes (160). 45
8. The tangentially fired boiler (300) of any one of claims 1 to 7, wherein the plurality of overfire air windboxes (330) in the horizontal orientation (340) comprises a height of less than two meters. 50
9. The tangentially fired boiler (300) of any one of claims 1 to 8, wherein the plurality of overfire air windboxes (330) comprises an air compartment (170) and a fuel compartment (180). 55
10. A method of operating a tangentially fired boiler (300), the tangentially fired boiler (300) comprising:

a combustion chamber (310); and
an overfire air system (320) positioned about the combustion chamber (310);
the overfire air system (320) comprising a plurality of overfire air windboxes (330);
the plurality of overfire air windboxes (330) comprising a horizontal orientation (340),
wherein the combustion chamber (310) comprises a wall (130) with a plurality of tubes therein (120),
wherein the plurality of tubes (120) comprises a spiral configuration (220),
wherein the spiral configuration (220) extends to a spiral to vertical transition line (260)
wherein the plurality of tubes (120) comprises a vertical configuration (250) above the spiral to vertical transition line (260),
wherein the overfire air system (320) is positioned above the spiral to vertical transition line (260), the method comprising:

combusting a flow of fuel and a flow of air in the combustion chamber (310);
circulating a fluid in the spiral configuration (220) around the combustion chamber (310); and
flowing overfire air into the combustion chamber (310) via the plurality of horizontal overfire windboxes (330) positioned above the spiral configuration (220).

Patentansprüche

- 35 1. Tangential befeuerter Kessel (300), umfassend:

eine Brennkammer (310); und
ein Oberluftsystem (320), das um die Brennkammer (310) positioniert ist;
wobei das Oberluftsystem (320) eine Vielzahl von Oberluftwindkästen (330) umfasst;
wobei die Vielzahl von Oberluftwindkästen (330) eine horizontale Ausrichtung (340) umfasst,
wobei die Brennkammer (310) eine Wand (130) mit einer Vielzahl von Rohren darin (120) umfasst,
wobei die Vielzahl von Rohren (120) eine spiralförmige Konfiguration (220) umfasst,
wobei sich die spiralförmige Konfiguration (220) zu einer spiralförmigen bis vertikalen Übergangslinie (260) erstreckt,
wobei die Vielzahl von Rohren (120) eine vertikale Konfiguration (250) über der spiralförmigen bis vertikalen Übergangslinie (260) umfasst,
wobei das Oberluftsystem (320) über der spiralförmigen bis vertikalen Übergangslinie (260) positioniert ist.

2. Tangential befeuerter Kessel (300) nach Anspruch 1, wobei die Vielzahl von Rohren (120) eine Vielzahl von Wasserrohren (120) umfasst.
3. Tangential befeuerter Kessel (300) nach einem der Ansprüche 1 bis 2, wobei die Vielzahl von Rohren (120) einen im Wesentlichen gleichmäßigen Abstand (350) umfasst. 5
4. Tangential befeuerter Kessel (300) nach einem der Ansprüche 1 bis 3, wobei die Brennkammer (310) eine Vielzahl von Windkästen (160) umfasst. 10
5. Tangential befeuerter Kessel (300) nach Anspruch 4, wobei die Vielzahl von Windkästen (160) ein Luftabteil (170) und ein Brennstoffabteil (180) umfasst. 15
6. Tangential befeuerter Kessel (300) nach Anspruch 4 oder 5, wobei sich die Vielzahl von Windkästen (160) um etwa dreißig Grad neigen und um etwa fünfundzwanzig Grad gieren kann. 20
7. Tangential befeuerter Kessel (300) nach einem der Ansprüche 4 bis 6, ferner umfassend eine Zufuhr von pulverisiertem Festbrennstoff (190), die mit der Vielzahl von Windkästen (160) in Verbindung steht. 25
8. Tangential befeuerter Kessel (300) nach einem der Ansprüche 1 bis 7, wobei die Vielzahl von Oberluftwindkästen (330) in der horizontalen Ausrichtung (340) eine Höhe von weniger als zwei Metern umfasst. 30
9. Tangential befeuerter Kessel (300) nach einem der Ansprüche 1 bis 8, wobei die Vielzahl von Oberluftwindkästen (330) ein Luftabteil (170) und ein Brennstoffabteil (180) umfasst. 35
10. Verfahren zum Betreiben eines tangential befeuerten Kessels (300), wobei der tangential befeuerte Kessel (300) Folgendes umfasst: 40
 - eine Brennkammer (310); und
 - ein Oberluftsystem (320), das um die Brennkammer (310) positioniert ist; 45
 - wobei das Oberluftsystem (320) eine Vielzahl von Oberluftwindkästen (330) umfasst;
 - wobei die Vielzahl von Oberluftwindkästen (330) eine horizontale Ausrichtung (340) umfasst, 50
 - wobei die Brennkammer (310) eine Wand (130) mit einer Vielzahl von Rohren darin (120) umfasst,
 - wobei die Vielzahl von Rohren (120) eine spiralförmige Konfiguration (220) umfasst, 55
 - wobei sich die spiralförmige Konfiguration (220) zu einer spiralförmigen bis vertikalen Übergangslinie (260) erstreckt,
 - wobei die Vielzahl von Rohren (120) eine verti-

kale Konfiguration (250) über der spiralförmigen bis vertikalen Übergangslinie (260) umfasst, wobei das Oberluftsystem (320) über der spiralförmigen bis vertikalen Übergangslinie (260) positioniert ist, wobei das Verfahren Folgendes umfasst:

Verbrennen eines Brennstoffstroms und eines Luftstroms in der Brennkammer (310); Zirkulieren eines Fluids in der spiralförmigen Konfiguration (220) um die Brennkammer (310); und
Einströmen von Oberluft in die Brennkammer (310) über die Vielzahl von horizontalen Oberluftwindkästen (330), die über der spiralförmigen Konfiguration (220) positioniert sind.

Revendications

1. Chaudière à chauffe tangentielle (300), comprenant :
 - une chambre de combustion (310) ; et
 - un système d'air surchauffé (320) positionné autour de la chambre de combustion (310) ;
 - le système d'air surchauffé (320) comprenant une pluralité de coffres d'air surchauffé (330) ;
 - la pluralité de coffres d'air surchauffés (330) comprenant une orientation horizontale (340), dans laquelle la chambre de combustion (310) comprend une paroi (130) avec une pluralité de tubes à l'intérieur (120),
 - dans laquelle la pluralité de tubes (120) comprend une configuration en spirale (220),
 - dans laquelle la configuration en spirale (220) s'étend jusqu'à une ligne de transition de spirale à verticale (260),
 - dans laquelle la pluralité de tubes (120) comprend une configuration verticale (250) au-dessus de la ligne de transition de spirale à verticale (260),
 - dans laquelle le système d'air surchauffé (320) est positionné au-dessus de la ligne de transition de spirale à verticale (260).
2. Chaudière à chauffe tangentielle (300) selon la revendication 1, dans laquelle la pluralité de tubes (120) comprend une pluralité de tubes d'eau (120).
3. Chaudière à chauffe tangentielle (300) selon l'une quelconque des revendications 1 à 2, dans laquelle la pluralité de tubes (120) comprend un espacement sensiblement uniforme (350).
4. Chaudière à chauffe tangentielle (300) selon l'une quelconque des revendications 1 à 3, dans laquelle

la chambre de combustion (310) comprend une pluralité de coffres d'air (160).

5. Chaudière à chauffe tangentielle (300) selon la revendication 4, dans laquelle la pluralité de coffres d'air (160) comprend un compartiment d'air (170) et un compartiment de carburant (180). 5
6. Chaudière à chauffe tangentielle (300) selon la revendication 4 ou 5, dans laquelle la pluralité de coffres d'air (160) peut s'incliner d'environ trente degrés et faire un mouvement de lacet d'environ vingt-cinq degrés. 10
7. Chaudière à chauffe tangentielle (300) selon l'une quelconque des revendications 4 à 6, comprenant en outre une alimentation en carburant solide pulvérisé (190) en communication avec la pluralité de coffres d'air (160). 15
20
8. Chaudière à chauffe tangentielle (300) selon l'une quelconque des revendications 1 à 7, dans laquelle la pluralité de coffres d'air surchauffé (330) dans l'orientation horizontale (340) comprend une hauteur inférieure à deux mètres. 25
9. Chaudière à chauffe tangentielle (300) selon l'une quelconque des revendications 1 à 8, dans laquelle la pluralité de coffres d'air surchauffé (330) comprend un compartiment d'air (170) et un compartiment de carburant (180). 30
10. Procédé de mise en œuvre d'une chaudière à chauffe tangentielle (300), la chaudière à chauffe tangentielle (300) comprenant : 35

une chambre de combustion (310) ; et
un système d'air surchauffé (320) positionné autour de la chambre de combustion (310) ;
le système d'air surchauffé (320) comprenant 40
une pluralité de coffres d'air surchauffé (330) ;
la pluralité de coffres d'air surchauffés (330) comprenant une orientation horizontale (340),
dans laquelle la chambre de combustion (310) comprend une paroi (130) avec une pluralité de 45
tubes à l'intérieur (120),
dans laquelle la pluralité de tubes (120) comprend une configuration en spirale (220),
dans laquelle la configuration en spirale (220) s'étend jusqu'à une ligne de transition de spirale 50
à verticale (260)
dans laquelle la pluralité de tubes (120) comprend une configuration verticale (250) au-dessus de la ligne de transition de spirale à verticale (260), 55
dans laquelle le système d'air surchauffé (320) est positionné au-dessus de la ligne de transition de spirale à verticale (260), le procédé

comprenant :

la combustion d'un flux de carburant et d'un flux d'air dans la chambre de combustion (310) ;
la circulation d'un fluide dans la configuration en spirale (220) autour de la chambre de combustion (310) ; et
l'écoulement d'air surchauffé dans la chambre de combustion (310) par l'intermédiaire de la pluralité de coffres d'air surchauffé horizontaux (330) positionnés au-dessus de la configuration en spirale (220).

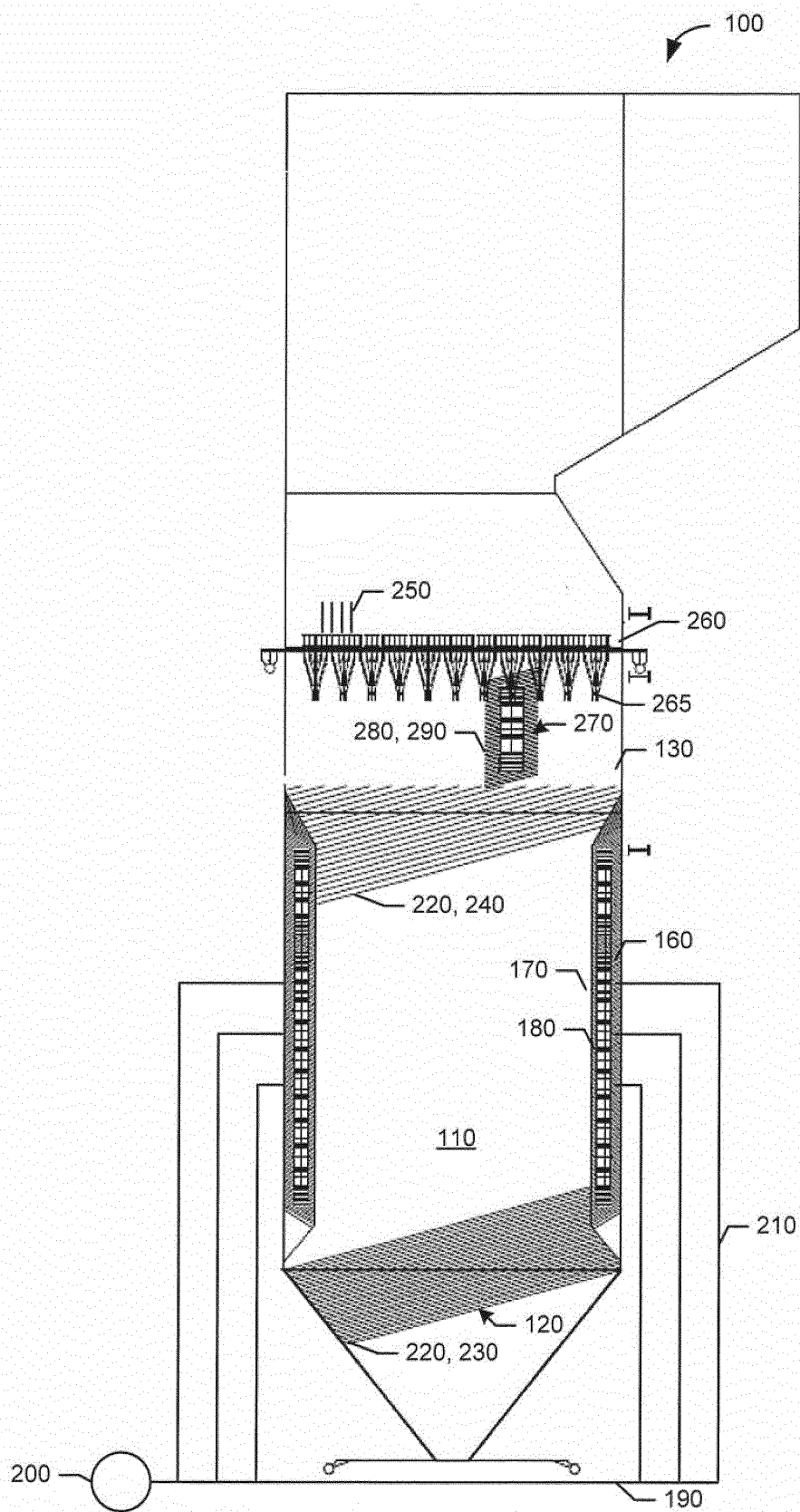


FIG. 1

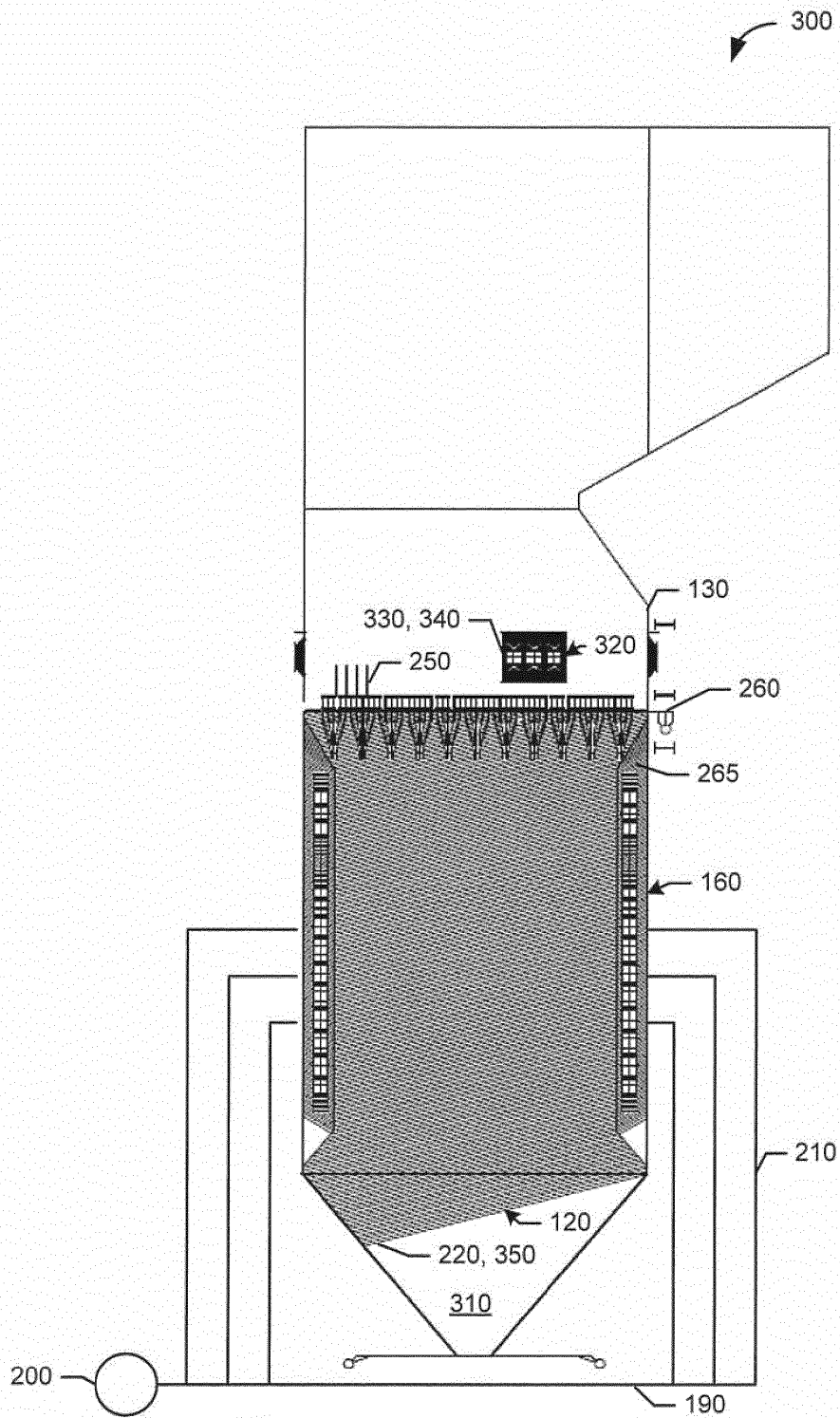


FIG. 2

REFERENCES CITED IN THE DESCRIPTION

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